

## Optical disc drive

## FIELD OF THE INVENTION

The present invention relates in general to a disc drive apparatus for writing/reading information into/from an optical storage disc; hereinafter, such a disc drive apparatus will also be indicated as "optical disc drive".

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## BACKGROUND OF THE INVENTION

For optically scanning the rotating disc, an optical disc drive comprises a light beam generator device (typically a laser diode), an objective lens for focusing the light beam in a focal spot on the disc, and an optical detector for receiving the reflected light reflected from the disc and for generating an electrical detector output signal. The optical detector usually comprises multiple detector segments, each segment providing an individual segment output signal. These individual segment output signals are transferred to a data processing circuit, for deriving data information and error signals.

Typically, an optical disc is designed for being scanned with a laser beam having one predetermined wavelength. On the other hand, different types of optical discs have been designed for being scanned with laser beams of mutually different wavelengths. For instance, optical discs for red light (650 nm) and for infrared light (780 nm) have been developed, and more recently the blue light disc was developed. It is desirable that a disc drive should be capable of handling optical discs of different types. Therefore, an optical pickup unit (OPU) of a multiple-type disc drive should have the capability of generating laser beams of different colors, and should have an optical system capable of handling light having different wavelengths.

In principle, it is possible that a single optical detector is used which is sensitive to a wide spectral range. However, this would imply that optical components (such as lenses, beam splitters, etc) should be designed to operate at different wavelengths, which is quite difficult. Therefore, the optical system of a multiple-type disc drive usually comprises different optical paths for the individual laser beams, including separate optical detectors for the individual laser beams. Each such separate optical detector may be sensitive to a wide

spectral range, but the separate optical detectors may also be sensitive to a narrow spectral range only, corresponding to the color of the respective laser beam.

It is also possible that an OPU comprises two optical detectors of the same color, one being used in the case of writing and the other being used in the case of reading.

5        A problem in all cases of an OPU having multiple optical detectors relates to the further processing of the output signals of the optical detectors in a further signal processing circuit, which typically takes place in an IC mounted on a PCB (the main PCB) located remote from the OPU. More specifically, the problem relates to economically coupling the multiple outputs of the multiple optical detectors to the single input of the signal  
10      processing circuit. In this respect, it is noted that each detector output actually involves an output port comprising a set of outputs, each such output being associated with a corresponding detector segment.

15      In one approach, each set of outputs of each optical detector is connected to the main PCB through a corresponding (flexible) cable. The signal processing circuit may be implemented as a special IC having two (or more) input ports, or by two (or more) standard single-input ICs.

20      In another approach, as described, for example, in EP-A-0.939.397, the multiple sets of detector outputs are connected to the main PCB through one common cable, in which case each detector output is selectively coupled to the corresponding cable wire via a controllable switch.

An important objective of the present invention is to provide a more cost-efficient solution to said problem.

## SUMMARY OF THE INVENTION

25      According to an important aspect of the present invention, two (or more) optical detectors having current outputs are used. Respective output terminals of different optical detectors are simply connected together and to one end of a wire of the coupling cable. The other end of said wire is connected to a corresponding input terminal of the signal processing circuit, which may be implemented as a standard single input port IC. For  
30      transforming the current signals to (standard) voltage signals, each coupling wire may be coupled to ground through a corresponding terminating resistor, which may be either integrated in the signal processing IC or implemented as an external resistor.

**BRIEF DESCRIPTION OF THE DRAWINGS**

These and other aspects, features and advantages of the present invention will be further explained by the following description with reference to the drawings, in which same reference numerals indicate same or similar parts, and in which:

5           Figure 1 schematically illustrates some relevant components of an optical disc drive apparatus;

              Figure 2 schematically illustrates an optical detector;

              Figure 3 schematically illustrates an optical disc drive apparatus according to the present invention;

10          Figure 4 is a block diagram schematically illustrating an optical detector system according to the present invention.

**DESCRIPTION OF THE INVENTION**

Figure 1 schematically illustrates an optical disc drive apparatus 1 suitable for 15 storing information on or reading information from an optical storage disc 2, typically a DVD or a CD. The optical disc 2 comprises at least one track (not shown for the sake of simplicity), either in the form of a continuous spiral or in the form of multiple concentric circles, of storage space where information can be stored in the form of a data pattern. The optical disc may be of the read-only type, where information is recorded during manufacture, 20 which information can only be read by a user. The optical disc may also be of a writable type, where information can be stored by a user. Since the technology of optical discs in general, the way in which information can be stored in an optical disc, and the way in which optical data can be read from an optical disc are commonly known, it is not necessary here to describe this technology in more detail.

25          For rotating the disc 2, the disc drive apparatus 1 comprises a motor 4 fixed to a frame (not shown for the sake of simplicity), defining a rotation axis 5. For receiving and holding the disc 2, the disc drive apparatus 1 may comprise a turntable or clamping hub 6, which in the case of a spindle motor 4 is mounted on the spindle 7 of the motor 4.

              The disc drive apparatus 1 further comprises an optical system 30 for scanning 30 tracks of the disc 2 with an optical beam. The optical system 30 comprises light beam generating means 31, 41 for generating light beams and an optical detector system 35 for receiving reflected light and generating an electrical output signal representing the amount of detected light.

More specifically, in the exemplary arrangement illustrated in Figure 1, the disc drive apparatus 1 is a multiple-type drive designed for handling at least two types of disc, i.e. CD as well as DVD, for example. The optical system 30 comprises a first light beam generating means 31 and a second light beam generating means 41, each typically a laser component such as a laser diode, arranged to generate a first light beam 32 and a second light beam 42, respectively. In the following, different sections of the optical path of a light beam 32, 42 will be indicated by characters a, b, c, etc. added to the respective reference numeral 32, 42.

The first light beam 32 passes through a first beam splitter 43, a second beam splitter 33, a collimator lens 37, and an objective lens 34 to reach (beam 32b) the disc 2. The first light beam 32b is reflected from the disc 2 (reflected first light beam 32c) and passes through the objective lens 34, the collimator lens 37, and the second beam splitter 33 (beam 32d) to reach a first optical detector 60 of the optical detector system 35.

The second light beam 42 is reflected by a mirror 44, passes through the first beam splitter 43, and then follows an optical path comparable to the optical path of the first light beam 32, indicated by reference numerals 42b, 42c. After having passed through the second beam splitter 33, the two beams 32 and 42 are separated, for example by a third beam splitter 45. The second light beam 42d reaches a second optical detector 70 of the optical detector system 35, for example via a second mirror 46, which second optical detector 70 may be located at a substantial distance of the order of a few centimeter from the first optical detector 60.

The objective lens 34 is designed to focus one of the two light beams 32b, 42b in a focal spot F on an information layer (not shown for the sake of simplicity) of the disc 2.

During operation, the light beam should remain focused on a track. To this end, the objective lens 34 is arranged so as to be displaceable in axial and radial directions, and the optical disc drive apparatus 1 comprises an actuator system 52 arranged for displacing the objective lens 34 with respect to the disc 2. Since actuator systems are known per se, while furthermore the design and operation of such actuator systems are not the subject of the present invention, it is not necessary here to discuss the design and operation of such actuator systems in great detail.

It is noted that means for supporting the objective lens with respect to an apparatus frame and means for displacing the objective lens are generally known per se. Since the design and operation of such supporting and displacing means are not the subject of the present invention, it is not necessary here to discuss them in great detail.

The disc drive apparatus 1 further comprises a signal processing circuit 90 having read signal inputs 91 and 91' for receiving read signals  $S_{R,1}$  or  $S_{R,2}$ , respectively, from the optical detector system 35. The signal processing circuit 90 is designed to process the read signals  $S_{R,1}$  or  $S_{R,2}$  in order to derive a data signal  $S_D$  and to provide this data signal  $S_D$  at a data output 92. The signal processing circuit 90 is further designed to process the read signals  $S_{R,1}$  or  $S_{R,2}$  in order to generate control signals  $S_C$  for the actuator system 52, and to provide these control signals  $S_C$  at a control output 94.

Figure 2 illustrates that an optical detector X normally comprises a plurality of detector segments. In the example shown, the optical detector X comprises four detector segments  $X_a, X_b, X_c, X_d$  capable of providing individual detector signals A, B, C, D indicating the amount of light incident on each of the four detector quadrants, respectively. Since such a four-quadrant detector is commonly known per se, it is not necessary here to give a more detailed description of its design and functioning.

It is noted that different designs for the optical detector X are also possible. Specifically, it is noted that the optical detector may have central aperture segments and satellite segments, as will be clear to those skilled in the art. Also, it is noted that the disc drive apparatus may be part of a one-spot beam detection system, or of a 3-spot beam detection system, as will be clear to those skilled in the art.

Figure 2 also illustrates that the read signal input 91 of the signal processing circuit 90 actually comprises a plurality of inputs for receiving all individual detector signals. Thus, in the illustrated case of a four-quadrant detector, the read signal input 91 of the signal processing circuit 90 actually comprises four inputs 91a, 91b, 91c, 91d for receiving said individual detector signals A, B, C, D, respectively. The signal processing circuit 90 is designed to process said individual detector signals A, B, C, D in order to derive data and control information therefrom, as will be clear to those skilled in the art.

If the disc drive apparatus 1 only comprises one single optical detector X, the detector segments may be simply connected to the corresponding inputs 91a, 91b, 91c, 91d of the signal processing circuit 90 in a straightforward manner, as illustrated in Figure 2. However, a problem arises in the case of an optical detector system 35 suitable for different wavelengths. In the apparatus as illustrated in Figure 1, the signal processing circuit 90 has two separate read signal inputs 91 and 91' for receiving read signals  $S_{R,1}$  or  $S_{R,2}$  from the optical detectors 60 and 70, respectively. Each optical detector 60, 70 is connected to the corresponding read signal input 91, 91' via an individual cable 64, 74 (each cable comprising multiple wires, as will be clear to those skilled in the art).

Figure 3 is a diagram comparable to Figure 1, illustrating a disc drive apparatus 101 according to the present invention, which is identical to the apparatus 1 as discussed above, except that the signal processing circuit 90 has only one read signal input 91, and both optical detectors 60, 70 are connected to this signal input 91 via one common cable 81 (comprising multiple common wires 81a-d), as will be explained in more detail with reference to Figure 4.

Figure 4 is a block diagram schematically illustrating an optical detector system 35 according to the present invention. This optical detector system 35 comprises a plurality of optical detector units, in this case two optical detector units 60 and 70, each comprising an array 61, 71 of multiple detector segments 62a, 62b, 62c, 62d and 72a, 72b, 72c, 72d, respectively. Figure 3 only shows four detector segments in each detector array 61, 71, but it should be clear that this is for purposes of illustration only without limiting the scope of the present invention.

Each optical detector unit 60, 70 has a plurality of output terminals 63a, 63b, 63c, 63d and 73a, 73b, 73c, 73d, respectively, each terminal being associated with a corresponding detector segment. Output terminal 63a (63b/63c/63d) of first optical detector unit 60 is connected to a corresponding output terminal 73a (73b/73c/73d) of second optical detector unit 70 at a node 80a (80b/80c/80d), which forms an output node of the optical detector system 35, which output node 80a (80b/80c/80d) is connected to a corresponding input terminal 91a (91b/91c/91d) of the signal processing circuit 90 via one line 81a (81b/81c/81d) of common cable 81.

According to an important aspect of the present invention, the optical detector units 60 and 70 are of a type that has current outputs, i.e. the output signals provided at their respective output terminals 63a-d and 73a-d are current signals. During operation of the disc drive apparatus 2, only one of the optical detector units 60 and 70 is operative, as determined by the identity of the laser 31, 41 in use. The other, non-operative detector unit, by virtue of the fact that it does not receive light, is in a "Power Down Mode", in which its outputs are floating, or in any case provide a high input impedance. Thus, the presence of the non-operative detector unit does not affect the output signals produced by the operative detector unit.

The signal processing circuit 90 may be a circuit having current inputs, i.e. designed to process current signals. However, the signal processing circuit 90 may alternatively be a standard circuit having voltage inputs, i.e. designed to process voltage signals. In this case, as shown, each line 81a (81b/81c/81d) is coupled to ground via a

corresponding terminator resistor 82a (82b/82c/82d). Such terminator resistors may be located on board the optical detector system 35, but preferably such terminator resistors are located in the proximity of the signal processing circuit 90. They may even be integrated on board the signal processing IC.

5 The resistance value of each terminator resistor 82a (82b/82c/82d) may conveniently be chosen to match the characteristic impedance of the corresponding line 81a (81b/81c/81d), in order to improve the robustness of signal transport at high bandwidth.

10 It is noted that, in the illustrative example of Figures 1 and 3, the optical paths of the two light beams 32 and 42 are largely comparable, while the two light beams 32 and 42 are focused by the same lenses 37 and 34 so that the focal points F for the two light beams substantially coincide. Alternatively, different optical components may be used for the two light beams, so that the optical system 30 contains two separate optical paths for the two light beams 32 and 42 and the focal points F for the two light beams do not coincide. Optical separation components like the third beam splitter 45 may then be omitted.

15 In an embodiment where the light beams are completely separated, it is possible to provide separate optical units 130, each unit comprising a laser unit such as 31, an optical lens such as 34, and an optical detector such as 60. Such units may be mounted in an optical disc drive apparatus 101 in which the current outputs of the individual optical detectors are connected together, as described above.

20 It will be clear to those skilled in the art that the present invention is not limited to the exemplary embodiments discussed above, but that several variations and modifications are possible within the protective scope of the invention as defined in the appending claims.

25 For instance, although it is preferred that the optical detector units 60 and 70 are of mutually identical design, except perhaps for their wavelength sensitivity ranges, while it is also preferred that all corresponding output terminals of the optical detector units 60 and 70 are connected together, as illustrated, an advantage within the context of the present invention is already achieved if only one current output of the first detector unit 60 is connected to one corresponding current output of the second detector unit 70.

30 Furthermore, although the present invention has been explained for an illustrative example having two light beams, it should be clear that the present invention may equally well be implemented in an apparatus having three or more light beams.

In the above, the present invention has been explained with reference to block diagrams, which illustrate functional blocks of the device according to the present invention.

It is to be understood that one or more of these functional blocks may be implemented in hardware, where the function of such a functional block is performed by individual hardware components, but it is also possible that one or more of these functional blocks are implemented in software, so that the function of such a functional block is performed by one or more program lines of a computer program or a programmable device such as a microprocessor, microcontroller, digital signal processor, etc.